Space Weather Technical Forecast

Issued on Friday 4 October 2024 at 13:30 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1-R2 Blackouts expected, chance of further X-class flares and R3 Blackouts. G1-G2/Minor-Moderate Geomagnetic storms likely, Chance G3/Strong Geomagnetic storm Days 2 and 3.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High, with the background irradiance just below M-class level, and numerous M-class flares. The largest flare was a X9.0 flare observed at 03/1218 UTC, which originated from AR3842 near south-centre disc.

There are currently eleven active sunspot regions on the visible disc, of which ten are numbered. AR3842 and AR3844, both in the southwest disc, are the most complex regions with beta-gamma-delta configurations. AR3842 consists of a large and complex lead portion and, prior to the X9.0 flare on 03 Oct, exhibited potential sigmoid characteristics. AR3844 retains a delta configuration, however, the strong delta region in the rear of the sunspot group has become marginal due to separation between the umbrae; smaller delta spots have formed in the lead and rear portions, but are less significant. The largest region on the disc is AR3848, in the northeast. This region is close to the northeast limb which means confidence is low for its classification due to the viewing angle. Another region also tricky to analyse, due to its proximity to the east limb, is a NEW region that appears to have the potential to be magnetically complex. The remaining numbered regions are smaller and appear relatively benign, although AR3843 in the southwest produced a M6.7 flare on 03/2028 UTC and cannot be discounted from producing further flares.

The X9.0 flare from AR3842 produced a CME, which is forecast to reach Earth later on 05 Oct or during early 06 Oct. Further CMEs evident on coronagraph imagery from early 04 Oct may also have had Earth-directed components, analysis of these features are underway.

Solar Wind / Geomagnetic Activity: Solar wind parameters were indicative of a slow regime. Solar wind speeds ranged between approximately 310 and 390 km/s, but are approaching slightly elevated levels. Density was below average throughout. The Interplanetary Magnetic Field, Bt, was predominantly at weak levels, but briefly peaked at Moderate levels reaching 9nT at 03/1733 UTC. The north-south component Bz, remained weakly fluctuating with values below +/-7nT. Phi angle was predominantly negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

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Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 was at background levels. High energy electron flux (greater than 2MeV) observed by GOES16 was at background to moderate levels (at diurnal peak), with a peak value of 268 pfu at 03/1330 UTC. The associated 24-hour fluence was below the Active threshold.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Moderate, with further M-class flares expected and a chance of returning to High should another isolated X-class flare occur, these most likely originating from AR3842 or AR4844.

Solar Wind / Geomagnetic Activity: The expected glancing CME from 29 Sep appears to have missed Earth. A glancing blow from the X7.1 flare CME is likely on later Day 1 or during Day 2 (04-05 Oct). The arrival of a CME from the 03 Oct X9.0 flare is more confident, arriving either late on the Day 2 or during Day 3 (06 Oct). One or more further CME arrivals are possible Day 4 (07 Oct) following filament disruptions and flaring observed late 03 and during 04 Oct, but analysis of these features is ongoing.

Solar wind speeds remaining at Background initially, rising to Slightly Elevated or Elevated during Days 2-3 due to expected CME arrivals. Slight chance of reaching 600-650 km/s late Day 2 or Day 3 due to combined influence of multiple CME arrivals.

Quiet (Kp 0-2) geomagnetic conditions initially, increasing G1-G2/Minor-Moderate Geomagnetic Storm (Kp 5-6) at times from late today and through the rest of the period. This is due to the forecast arrivals of the X7.1 CME and then the X9.0 CME, but also the potential of further CME arrivals later Days 3-4 (06-07 Oct). There is a chance of G3/Strong Geomagnetic Storm (Kp 7) conditions occurring, mainly from late on Day 2 into Day 3, with a slight chance of isolated G4/Severe Geomagnetic storm (Kp 8) intervals.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 is forecast to persist at background with a chance of rising above should further significant flares occur. High energy electron flux at GOES16 is expected to persist at Background to Moderate levels. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 total pfu), throughout.

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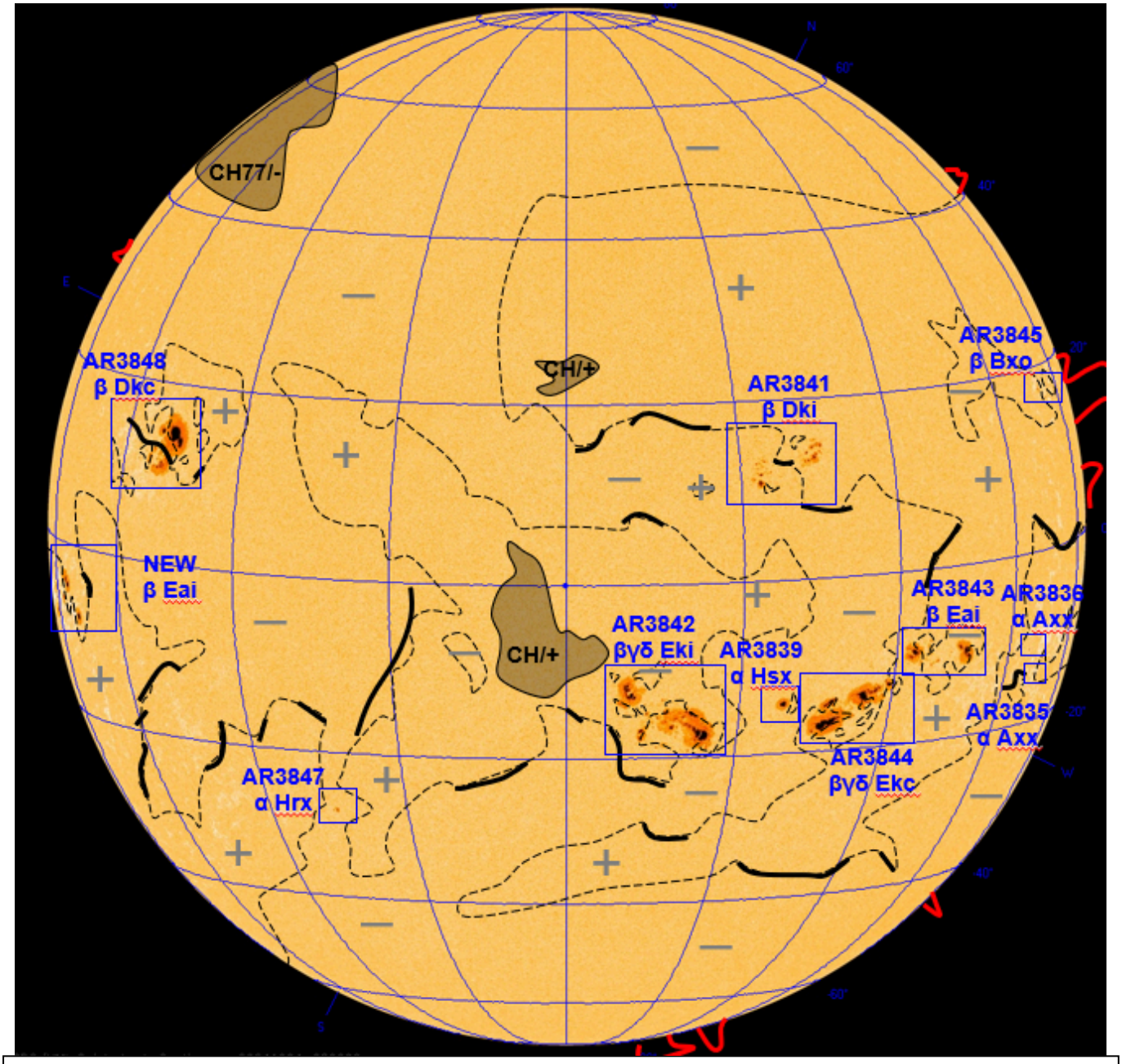
Figure 1: Synoptic Map valid 04/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

A glancing blow from the X7.1 flare on 01 Oct CME is forecast to arrive later Day 1 or early Day 2 (04-05 Oct) with the bulk of the CME expected to pass to the south of Earth. The arrival of a CME from the 03 Oct X9.0 flare has greater confidence, with a more direct hit expected, arriving either late on Day 2 or early on Day 3 (06 Oct). A number of M-flares have also produced CMEs that are visible on coronagraph imagery from earlier on 04 Oct, analysis of these features is underway with the anticipation of Earth-directed components given the source regions positions in the western hemisphere. Rudimentary analysis shows the potential arrival of a CME on Day 4 (07 Oct) attributed to the M6.7 flare from AR3843.

Quiet (Kp 0-2) geomagnetic conditions are expected at first, increasing G1-G2/Minor-Moderate Geomagnetic Storm (Kp 5-6) from late today or early tomorrow and throughout much of the rest of the period. This is due to the forecast arrivals of the X7.1 CME and then the X9.0 CME, but also the potential of further CME arrivals later Days 3-4 (06-07 Oct). There is a chance of G3/Strong Geomagnetic Storm (Kp 7) conditions occurring, mainly from late on Day 2 into Day 3, with a slight chance of isolated G4 (Kp 8) intervals due to the combined effect of both CME arrivals.

Solar wind speeds are expected to remain close to background levels initially, rising upon arrival of the first CME to 400-450km/s. A more substantial rise in wind speeds is possible with the combined effects of CME arrivals later Day 2 or Day 3, likely reaching Elevated levels with a slight chance of Strong levels (600-650 km/s). Speeds are then expected to gradually decline as enhancement from these arrivals wanes. Enlil is considered to be about 100 km/s too fast, with only the trend considered good guidance at this stage.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	50	80	80	60
Strong	**G3**	No	5	50	50	5
Severe	**G4**	No	1	20	20	1
Extreme	**G5**	No	1	5	5	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
02/0938	Partial	AR3842	SE	800	04/2300 UTC	Low confidence based on estimates. +/- 12hrs arrival time.
03/1637	Full	AR3842	SW	882	05/1800 UTC	High confidence for being Earth directed, lower confidence arrival time.

Figure 2: MOSWOC Enlil showing arrivals 04-06 Oct.

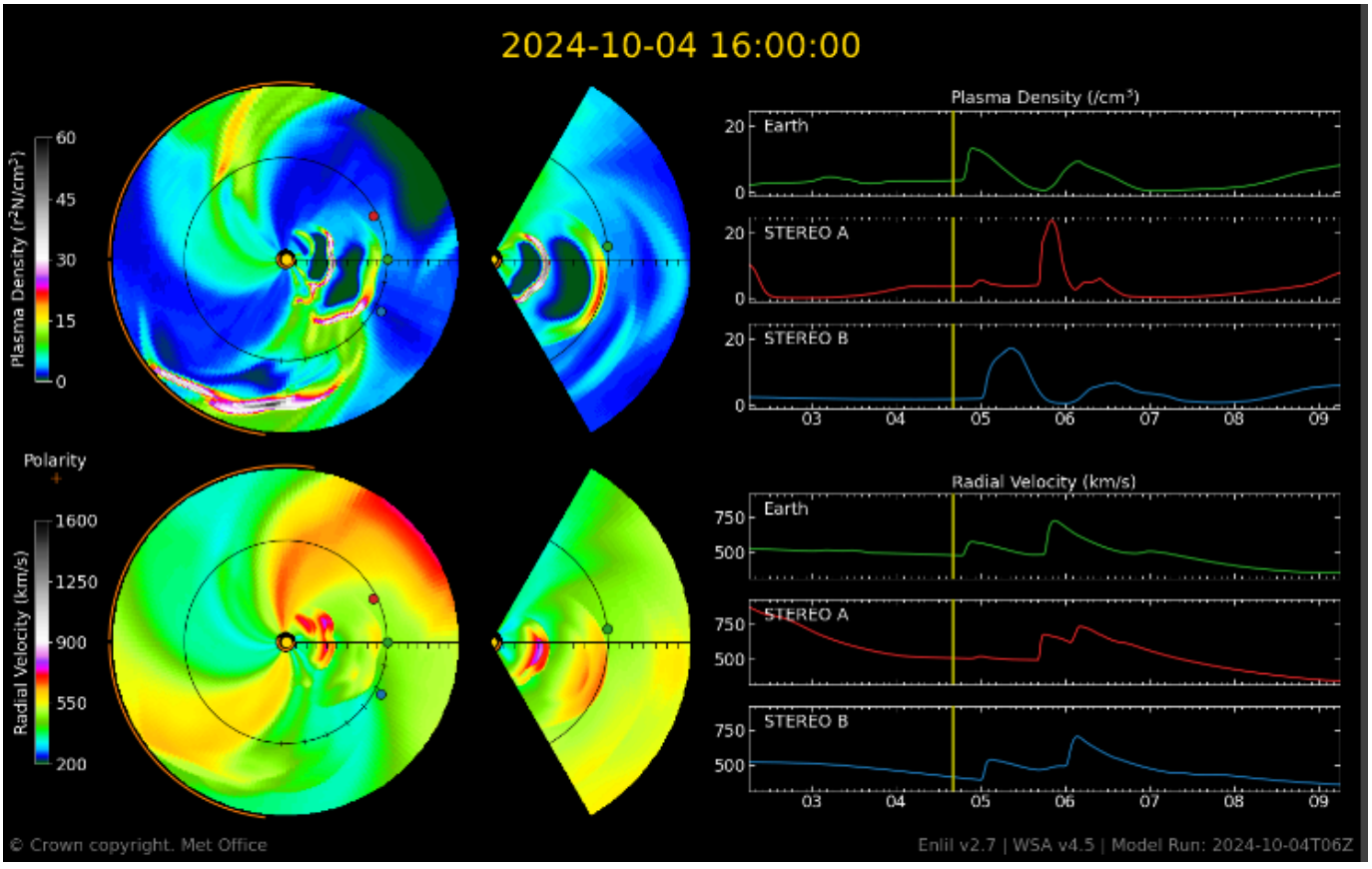

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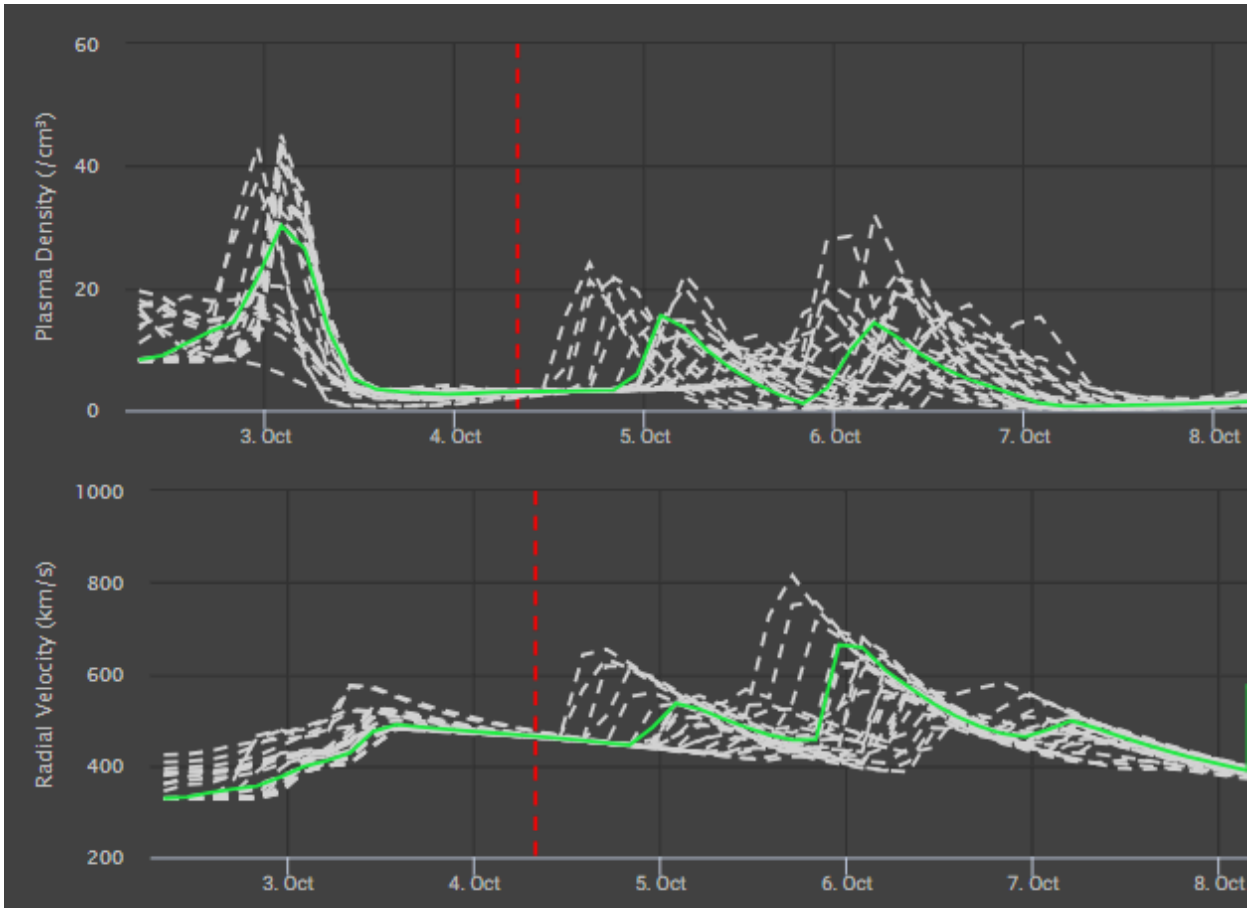
Figure 3: MOSWOC Enlil ensemble showing a range of solutions and arrival times of features between 04 and 07 Oct.



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Radio Blackouts - X-Ray Flares

There are currently eleven sunspot regions on the visible disc. The most complex regions both lie in the southwest quadrant; AR3842 (Eki/Beta-Gamma-Delta) with an obvious delta spot within the larger leader spot, and AR3844 (Ekc/Beta-Gamma-Delta. AR3842 consists of a large and complex lead portion and, prior to the X9.0 flare on 03 Oct, exhibited potential sigmoid characteristics. AR3842 has seen some consolidation and proliferation of small spots since last analysis, but is otherwise unchanged. AR3844 has seen some longitudinal growth with the region trending towards Eki. The strong delta region in the rear of the sunspot group has become marginal due to separation between the umbrae; smaller delta spots have formed in the lead and rear portions, but are less significant. AR3841, located in the northwest, previously contained an elongated delta spot in the trailing portion. However, this region has since decayed to a beta configuration, with two clusters of small spots at each end of the group. AR3848, close to the northeast limb, remains the largest region on the disc, with one large leader followed by several trailing portions, but classification still remains low confidence due to the foreshortening effects. The remaining numbered regions are smaller and appear relatively benign. However, a new region appearing on the east limb looks potentially large and complex, with at least two spots with penumbra, but is too close to the limb for accurate analysis. No significant regions are forecast to rotate beyond the western limb during the period, with the emerging region close to the eastern limb the main feature expected to rotate onto the disc during the next four days.

Solar activity has been High, with the background irradiance levels remaining close to, but below, M-class levels. The largest flare was a X9.0 flare observed at 03/1218 UTC, which originated from AR3842 near south-centre disc. A M6.7 flare also occurred at 03/2028 UTC from AR3843, which cannot be discounted from producing further flares. A M4.0 occurred at 04/0455 UTC emanating from AR3844. Frequent, smaller, M-flares have also been observed during the past 24hours.

Activity is expected to be Moderate, with further M-class flares expected and a chance of High should another isolated X-class flare occur. The risk of strong flares comes mostly from AR3842 or AR3844, with forecast values held higher than raw probabilities due to the high background x-ray flux level, past events and the strength and positioning of delta spots in each of the aforementioned sunspots.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	85	85	85	85
Very Active	R3-R5 (X Class)	Yes	35	35	35	35

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Figure 4: SDO AIA 94 image showing the X9.0 flare, with the image being overwhelmed by the flux levels.

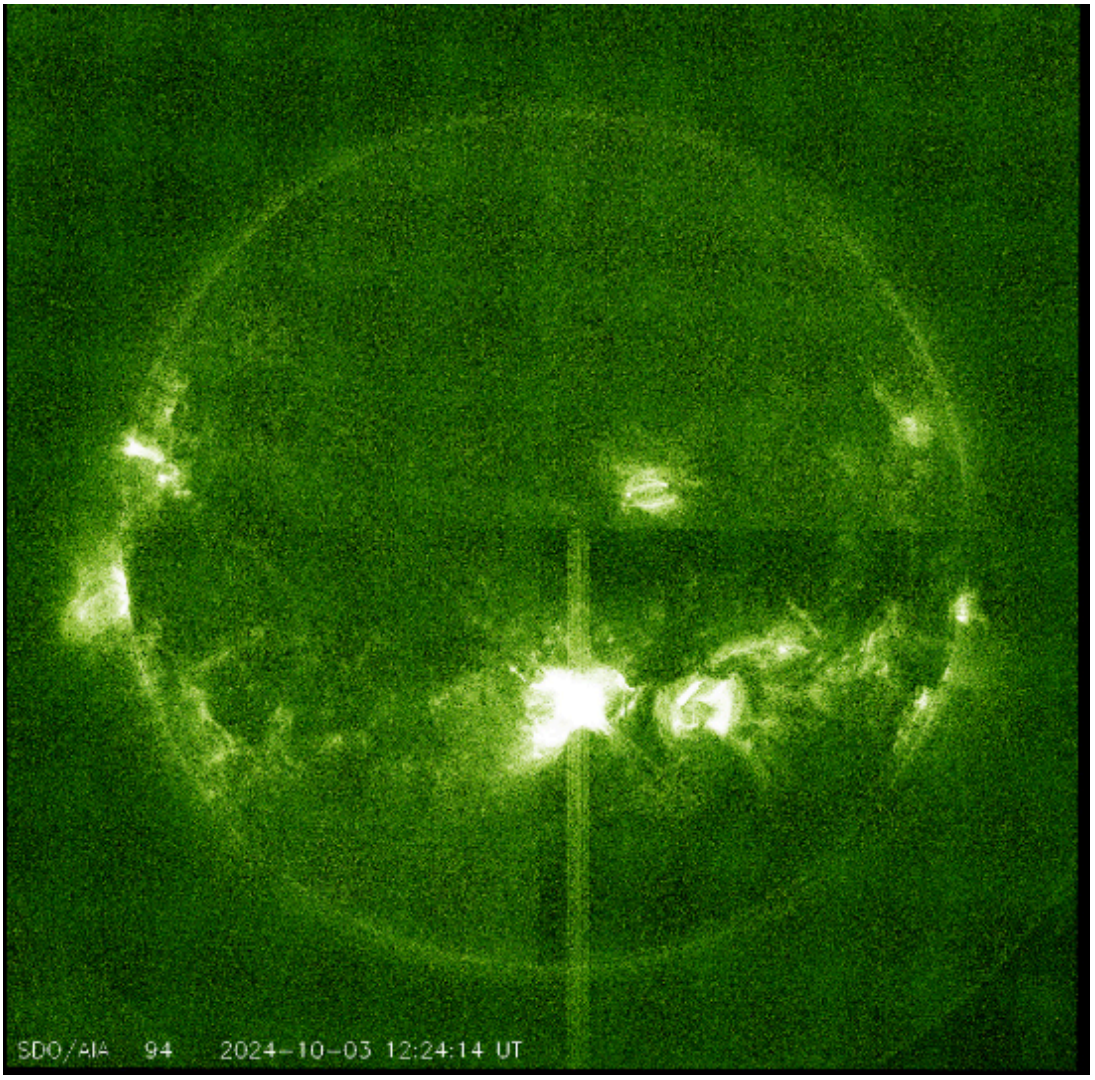

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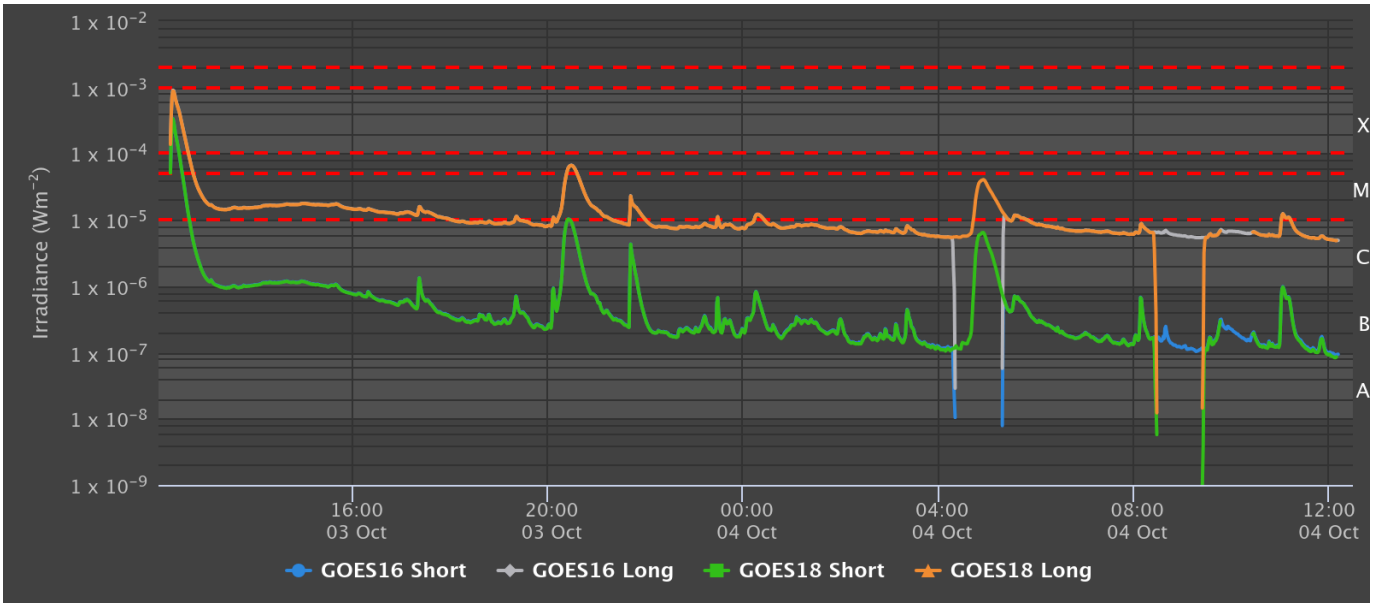
Figure 5: GOES16 and GOES 18 Xray trace over the past 24 hours



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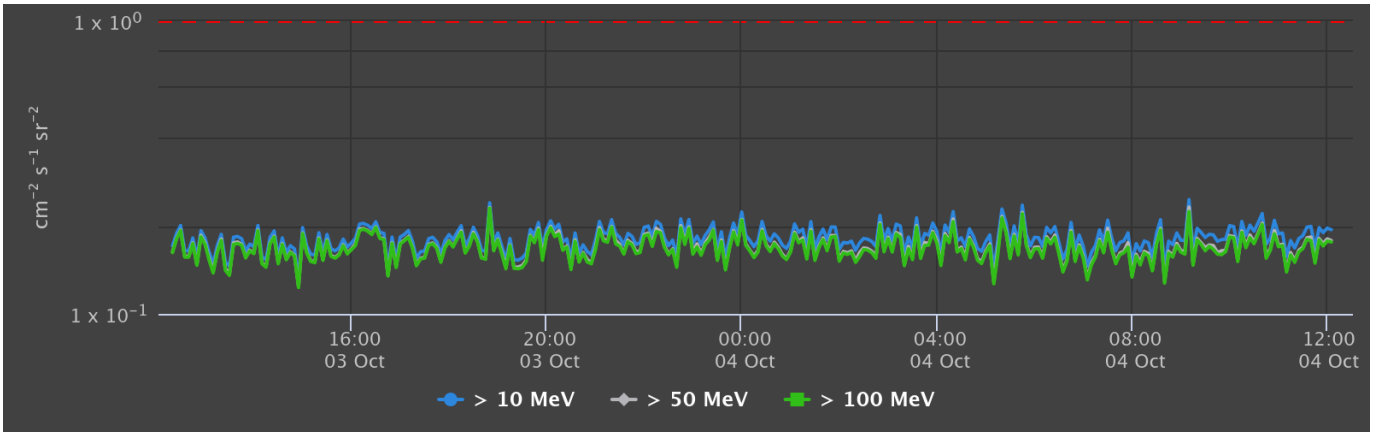
Solar Radiation Storms (High Energy Protons)

High energy proton flux at GOES18 is forecast to persist at background levels. No notable proton enhancement was observed following the X7.1 flare and associated CME nor the X9.0. There is a continued chance of Proton rich flares, mainly from AR3842 or AR3844, along with notable filaments on the disc also posing a risk should they erupt.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	25	25	25	25
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 6: GOES18 Proton Flux over the past 24 hours



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High Energy Electrons (≥ 2MeV)

High energy electron flux (greater than 2MeV) observed by GOES16 was at background to Moderate levels (at diurnal peak), with a similar trend expected through the four day period. Electron levels are likely to become suppressed following the predicted CME arrivals Days 1-3 (04-06 Oct), with observed levels unlikely to recover significantly until after the forecast periodl.

The associated 24 hour fluence is forecast to stay below Active (1e8 total pfu), in agreement with MOSWOC REFM.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 7: GOES16 Electron flux trace over past 24 hours.

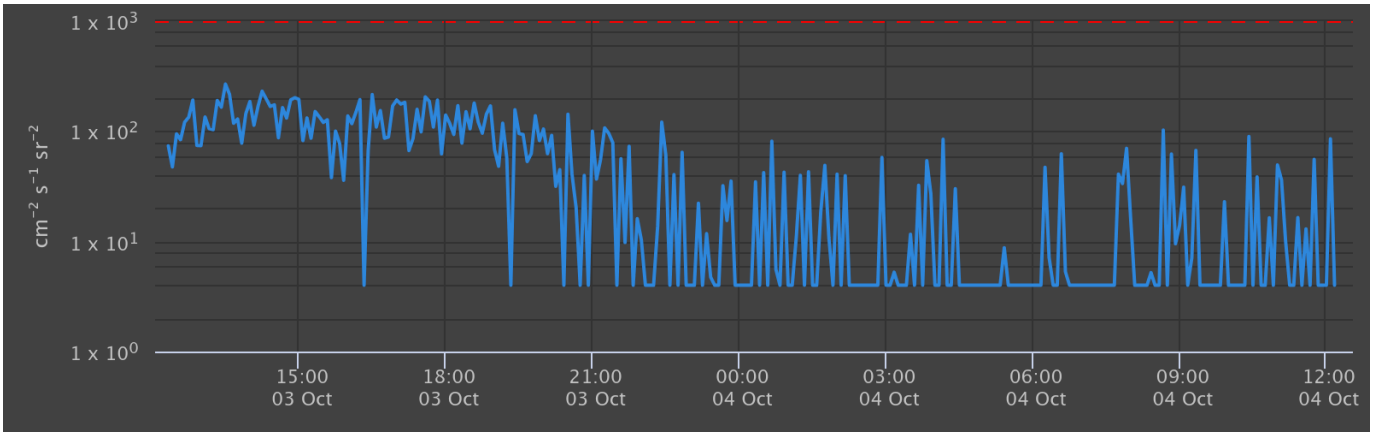

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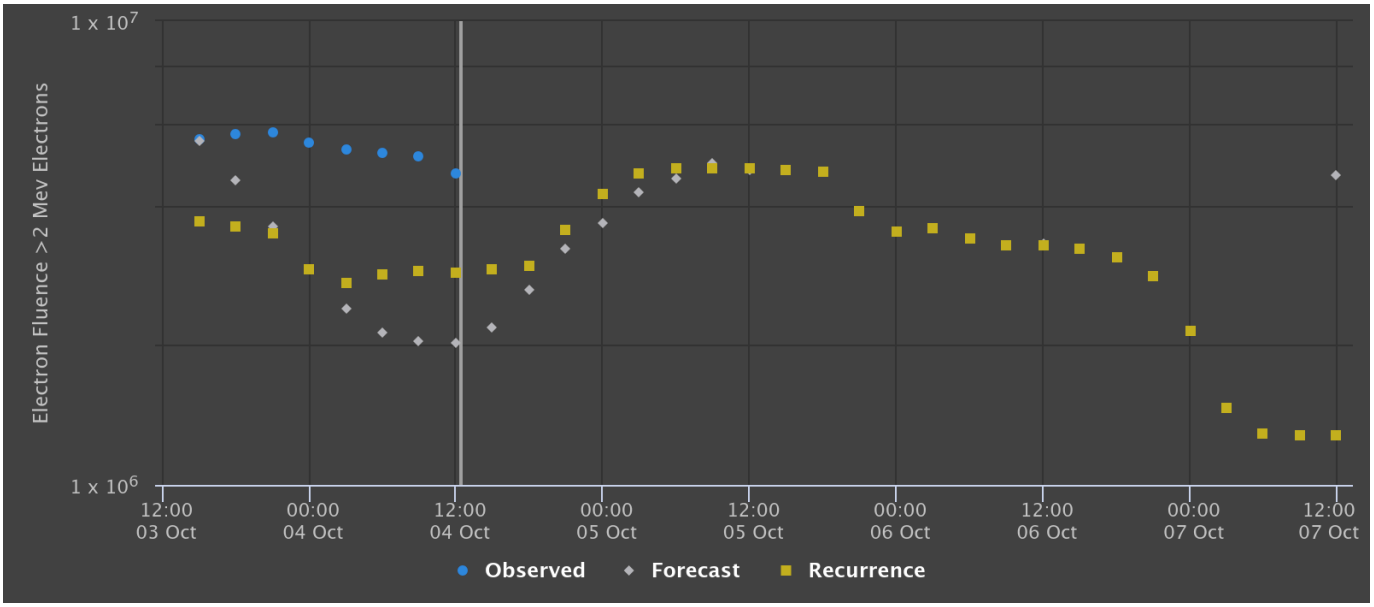
Figure 8: MOSWOC REFM showing values remaining below the Active threshold throughout.



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